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Population Dynamics and Its Relation to Ancient Landscapes in the Northwestern Maya Lowlands: Evaluating Resilience and Vulnerability

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ABSTRACT

In this article we present for discussion certain aspects of settlement and paleo-environmental data obtained over the last few years for the northwestern Maya lowlands. Accordingly, our goal is to identify a point of departure for future research by presenting a list of possible "environmental attractors" that might later be used for a better understanding of the seemingly divergent trajectories shown by ancient communities located in different physical settings—particularly in the Sierras region and the Usumacinta plains, Mexico. Our study is based on the paleo-pedological record of the region. Paleosols are good paleo-environmental proxies and, with the climate information, they are indicators of past human activities and land use. In the Maya lowlands, they have been used extensively to register changes in environmental conditions and human impact on the soil cover. Nevertheless, this study represents the first attempt in that same direction in the northwestern Maya lowlands. [settlement patterns, paleoenviromental reconstruction, northwestern Maya lowlands.]

Introduction

The presence of hydrographic elements is a salient feature in the geography of the northwestern Maya lowlands. The role of water in sediment transport and alluvial deposition has conditioned many of the morpho-genetic processes at the regional level, while much of natural vegetation and wildlife is aquatic. High levels of precipitation in the lowlands, foothills, and Chiapas mountains create a vast drainage network—coming in and

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out of lakes and swamps—that eventually empties into the Gulf of Mexico. This river system drains an area of 63,804 km^2 that includes parts of Tabasco, Chiapas, and Guatemala.

During prehispanic times, this broad region was the seat of many population centers. Through controlled surveys, we know of well over 2,300 archaeological sites (Figure 7.1). Presenting a range of human engineered features, these sites are located mainly in the plains of Tabasco; though a number of sites are surely located in the countless narrow valleys along the Usumacinta River within the Sierras region, an area currently poorly known. Although several archaeological sites recovered from this region correlate with the locations of contemporary population centers, insufficient archaeological data remains a concern in discussing aspects of the socio-political organization of the groups inhabiting the region in pre-Columbian times or their long trajectory of occupation.

Nevertheless, in this chapter we discuss certain aspects of settlement and paleo-environmental data obtained over the last few years for the northwestern Maya lowlands. Our goal is to identify a point of departure for future research by presenting a list of possible "environmental attractors" that might later be used for a better understanding of the seemingly divergent trajectories shown by ancient communities located in different physical settings—particularly in the Sierras region and the Usumacinta plains.

The Northwestern Maya Lowlands: An Archaeological Case Study

This vast region has been subdivided into two main areas: the Lower Usumacinta (from Boca del Cerro to its mouth in the Gulf of Mexico) and the Upper Usumacinta (from Boca del Cerro to the origins of the Usumacinta River in the confluence of the Salinas and Chixoy rivers). In prehispanic times, these geographical zones were the seat of many population centers. Nevertheless, the sociopolitical organization of the groups that inhabited this region in Precolumbian times is still difficult to address, simply because we know too little about their political and territorial organization, the characteristics of their adaptation to the environment, or the sequence of occupation and abandonment of this vast territory.

A yet more disturbing aspect of the history of archaeological research in this region is the overwhelming reliance in recent decades on epigraphic data. Our knowledge based on regional archaeological research is less than that gleaned from the hieroglyphic history. The research emphasis in the northwestern lowlands has focused mainly on a discussion of epigraphic evidence relating to a small number of issues concerning the identification of minor lords, dynastic sequences, relationship subordination of minor lords, royal visits, enthronement ceremonies, and the exchange of women of royal descent (Culbert 1991; Marcus 1976, 1993; Mathews 1991, Schele 1986, 1991; Schele and Freidel 1990; Grube and Martin 1998; Martin and Grube 2000). From these glyphic analyses, it has been argued that Palenque, Piedras Negras, Yaxchilan, and Pomona (among others) emerged as capitals of their respective areas of influence, but we still lack sufficient comparable archaeological information.

General Comments on the Ceramics and Chronology of the Lower and Upper Usumacinta

Ceramic research in the area has established a long sequence of occupation ranging from the Middle Preclassic period (800–300 B.C.E.) to the Terminal Classic period (C.E. 850). Robert Rands (1974, 1977) established the first and most reliable scheme of regional ceramic development based on his excavations at Yoxihá, Chinikiha, Miraflores, Tortuguero, and around Balancán Zapata, Tabasco. Rands' studies—and, more recently, the work of Sandra López at Pomona (2005), Marta Hernandez in the San Pedro River region (1981), and Socorro Jimenez (2009) in the Sierras region—confirm the existence of two ceramic traditions with dissimilar trajectories that coexisted in the Lower and Upper Usumacinta.

Since the early 1950s we have known that the Zapata-Balancán region presents a continuous trend of ceramic element incorporations belonging to the Chicanel ceramic sphere (Berlin 1955; Rands 1967; Ochoa 1978, 1984). Ochoa reported a series of sites in the Balancán Zapata region showing ceramic materials belonging to the Mamom and Chicanel ceramic spheres. These include El Mirador and Tiradero along the Rio San Pedro; and Pomoca, La Concepción, Povictuc, Nueva Esperanza, Río Frío, San José del Rio, and La Soledad Chacavita along the Usumacinta River (see Figure 7.1). The association of the Tabasco plains with ceramic types exhibiting a much wider distribution in the Maya Lowlands is a feature that continues through the long occupation sequence for the region. In contrast, the Sierras region (as Robert Rands used to call it) represents a more local ceramic development, showing marked regional differences. In the former region, the earliest pottery found by Rands (1967:134) and our project (Liendo 2008, 2011) comes from samples collected in caves near Chinikiha, and it is related to the waxy ceramic diagnostics of the Sierra Red group. Early Classic ceramics at Chinikiha and other

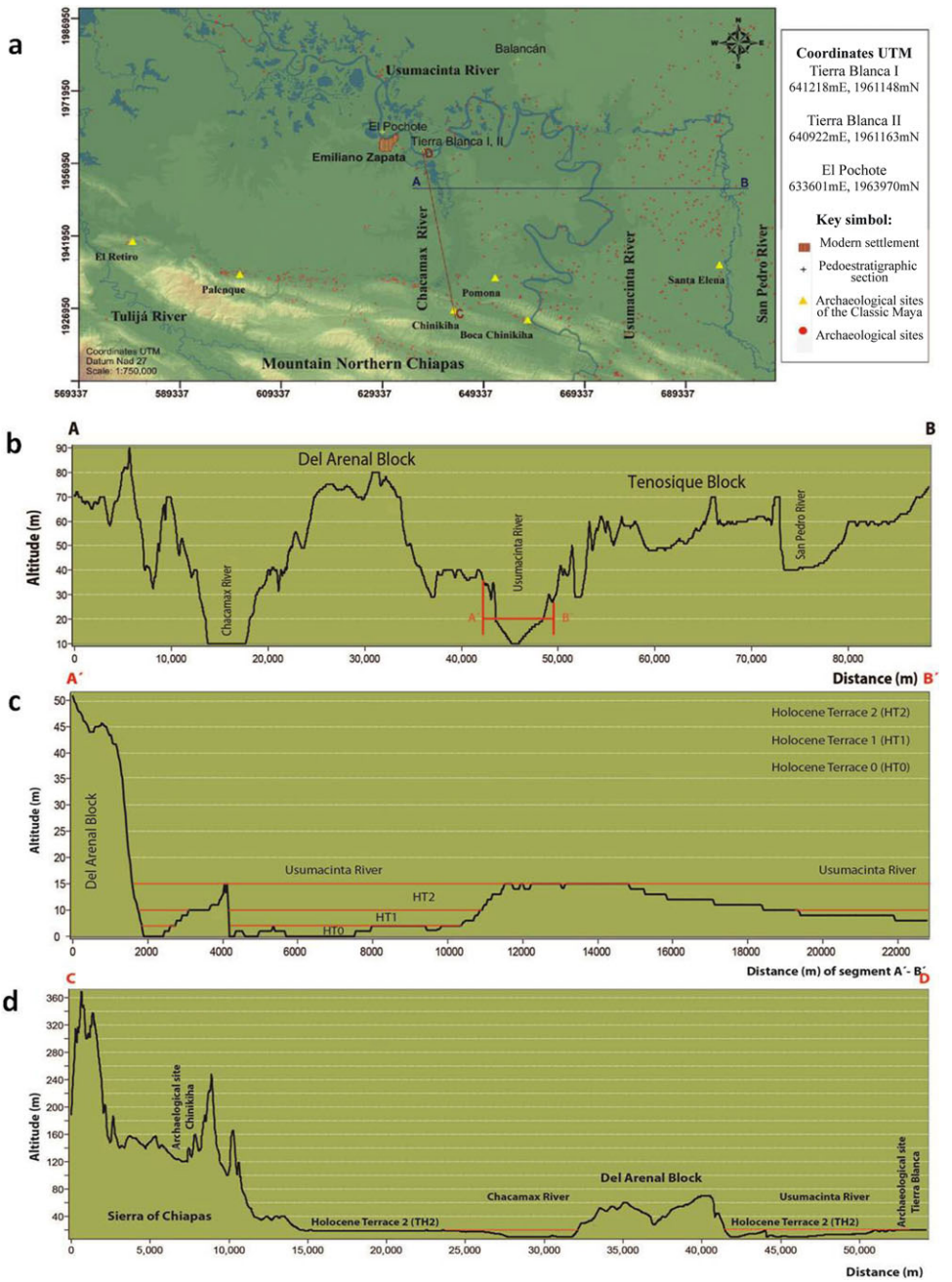

Figure 7.1. Northwestern Maya Lowlands and the Usumacinta River: (a.) study area showing: in circles, the archaeological sites; in triangles, the Classic big urban centers; and the pedological sections. (b.) A—B Cross section with W-E orientation showing the differences in altitude of fluvial terraces according to their age and controlled by tectonic activity; (c.) A´—B´cross section, representing the Holocene terraces in detail and close to the river bank; (d.) C—D cross section, with NW-SE orientation, representing the archeological site of Chinikihá in the Sierra de Chiapas.

settlements of Sierras, however, are more difficult to place. Currently, it is difficult to even establish an Early Classic occupation for the region. It is also unclear to what extent the Sierras Tzakol ceramics (scarce at Chinikiha) might be the result of sporadic ceramic intrusions. This scarcity of Early Classic ceramic material might also be due to inadequate archaeological sampling. Test pit excavations (N = 230) in the Palenque region (Liendo 2002, 2003, 2005) have sampled a

large number of settlements (N = 145) without encountering a major occupation for this period. Clearly, the Sierra de Chiapas shows a differing pattern of distribution for the better known Maya ceramic types (Rands 1967:138). Ceramic analysis demonstrates that the Sierras region (including settlements like Palenque, Chinikiha, Pomoná, and Yoxihá) is characterized during Late Classic times (C.E. 560–830) by a markedly regionalized ceramic distribution pattern when compared to other regions in the lowlands (Rands 1967).

Chronology and Population Dynamics in the Lower Usumacinta

The Preclassic Period (600 B.C.E.–C.E. 150)

Based on ceramic materials, we might envision a model of differential use for lowland riverine environments with communities showing an early and continuous development throughout the sequence in contrast to the low hilly landscape (Sierra), which shows a late and short-term explosive development. The rich alluvial banks of the Usumacinta River contain many of the early sites reported for the northwestern lowlands. Several factors may account for the high frequency of prehispanic sites close to the Usumacinta River and its tributaries, the Rio San Pedro and Chacamax. The existence of rich alluvial soils, the lack of evidence for destructive floods on natural banks, and the rich variety of lake resources available to prehispanic inhabitants of the region make the setting especially attractive.

A significant Middle Preclassic occupation has been detected in Trinidad and Tierra Blanca, Tabasco. In the Lower Usumacinta, the Middle Preclassic seems to have been a remarkable period of population growth. Major sites dating to this time—Tierra Blanca, Balancan, and Zapata—are located on the rich alluvial banks of the Usumacinta River. In this vast natural floodplain, Povictuc, La Carmelita, and Tierra Blanca appear to have been large centers straddling the river, as indicated by a series of small mounds located on both banks of the Usumacinta.

This scenario differs radically from the La Sierra region where no contemporary settlements have yet been found. However, our recent surveys have identified some 32 sites with abundant evidence of ceramics belonging to the Late Preclassic Chicanel period along the foothills of the Sierra de Chiapas and along the river Chacamax. If we compare the abundance of early ceramic contexts in Balancán Zapata with these few contexts in the Sierra, we might argue for a marginal demographic development at the regional scale during the Late Preclassic. During the Early and Middle Preclassic periods, it is highly probable that the Sierra region remained sparsely populated and was visited only sporadically by groups of individuals with permanent residency in the northern plains.

The Early Classic Period (C.E. 150–550)

The Sierras Early Classic pottery found in archaeological contexts presents a situation that is difficult to interpret. The Sierras region differs in fundamental ways from better known ceramics from other sectors of the Maya area. During the Early Classic period, settlements appear to be preferentially clustered in low-lying riverine environments along the Lower Usumacinta. With time, populations concentrated in a small number of centers. Following the foothills of the Sierra de Chiapas and intermountain valleys, Chinikiha, Palenque, Santa Isabel, La Cascada, San Juan Chancalaíto, La Reforma, El Retiro, Nututun, Sulusum, and Miraflores (see Figure 7.1) were all settled by the end of the Early Classic period. Along the rivers of the Usumacinta and San Pedro, there are several important sites with evidence of occupation during this period: Pomona, Morales-Reforma, San Claudio, and Santa Elena. The Usumacinta River and the Rio San Pedro seem to have exerted a strong force of attraction to people seeking expedient and appropriate transportation routes. The Early Classic period represents a time of significant population growth along the Usumacinta River and in the Sierra region. It also represents the emergence of important local dynasties at Palenque, Piedras Negras, Yaxchilan, Pomona, Reforma, and certainly Chinikiha—all sites with great influence in later times.

The Late Classic Period (C.E. 550–830)

During the Late Classic period, there was a change in the correlation between the populations living within larger settlements and overall regional population figures. Some researchers (Bishop 1994; Liendo 2002; Rands et al. 1982) argue this evidence is strong enough to suggest that sites like Palenque experienced a marked population increase during the Terminal Classic. Such population spikes may have been the logical result of people searching for new lands, although the evidence is not conclusive in this regard. Whether or not there was a population increase from the Late to Terminal Classic periods requires more detailed demographic studies. The settlement pattern indicates a trend toward the abandonment of nucleated settlements—clear in the case of Palenque, Chinikiha, and Pomoná, but a phenomenon that remains to be demonstrated elsewhere in the northwestern Lowlands—that created a more dispersed pattern than that

characteristic of Early Classic times, with settlements occupying spaces near agricultural fields.

The Terminal Classic is characterized by the introduction of a fine paste ceramic tradition, mainly orange ceramic groups related to the Altar, Balancan, and Silho ceramic types. This ceramic phase is underrepresented in the region, with only a few sherds found in la Sierra region at Palenque, Miraflores, and Pomoná. Chinikiha is completely devoid of ceramic material that can be associated with this period. It is evident that the Terminal Classic was a time of substantial decrease in population levels throughout the northwest of the Maya lowlands. Sites located near the Usumacinta River (Balancan, Calatrava, and Trinidad) appear to have survived and prospered into Postclassic times, but, overall, the Terminal Classic represents the end of most sizable communities—Palenque, Piedras Negras, Yaxchilan, Pomona, Morales-Reforma, and Chinikiha—as centers of political importance in the region.

The Paleo-Environment Setting of the Northwestern Maya Lowlands

Paleo-environmental studies in the northwestern Maya lowlands are scarce. Most of the information available for this area has been derived from reconstructions made in Guatemala and Belize. Given the high variability found in modern ecosystems (Ortiz-Pérez et al. 2005), these studies can only be provisionally utilized. There studies include the interpretation of lacustrine records from lake basins in Guatemala and Belize, covering the Late Pleistocene–Early Holocene (Correa-Metrio et al. 2012; Hodell et al. 2005; Hodell et al. 2008; Leyden et al. 1994; Rosenmeier et al. 2002) and, with more detail, the Late Holocene (Gill 2000; Haug et al. 2003; Hodell et al. 1995, 2005). According to these data, climate was highly variable during the last 36,000 years, and neither homogeneous in space nor time.

In general, the environmental conditions for Late Pleistocene–Early Holocene are characterized as humid with a progressive drying trend that began about 4000 years ago (Mueller et al. 2009) and created droughts that affected Maya populations (Gill 2000; Haug et al. 2003; Hodell et al. 1995, 2005). These data document that severe pulses of aridity occurred at the end of both the Late Preclassic and Classic periods, recorded not only in lacustrine sediments (Gunn et al. 1995; Hodell et al. 2001) but also in stalagmites of the Macal Chasm caves in Belize (Webster et al. 2007) and sediments of the Ix Chel cave in Belize (Polk et al. 2007). Dunning and Beach (2010) indicate that intense drought periods affected the Maya Lowlands in the fourth century B.C.E. and in the second, sixth, ninth, and eleventh centuries C.E., as well as in the more recent Little Ice Age. Both paleo-environmental records and archeological evidence show a strong correlation in terms of societal change in the Maya Lowlands associated with these periods.

Regional Setting—The Usumacinta River

The Usumacinta River is located in the southeastern part of Mexico. It runs from the south, starting in Guatemala, to the northeast into the Gulf of Mexico (see Figure 7.1). The river crosses through a mountain range belonging to Sierra de Chiapas that is constituted primarily by Tertiary folded limestones with their folding axis oriented northwest-southeast. The river then continues to the north through the alluvial plain of Tabasco. In the Sierra de Chiapas, the river runs mainly underground because of the karstification processes involving dissolution and infiltration rather than runoff. Consequently, water availability is more limited. Present environmental conditions vary according to the landforms. Near mountain ranges, precipitation is 2000 mm per year; in the alluvial plain, precipitation is slightly lower at 1800 mm per year. The region has an annual mean temperature of 27°C. The distribution of vegetation corresponds with this variability; evergreen tropical rainforest is found in the mountainous area, and grasses and aquatic species occur in the alluvial plain (Bueno and Santiago 2005; Rzedowski 2006).

The main tributaries of the Usumacinta system follow the planes of normal faults: San Pedro in the eastern part, Chakamax in the center, and Tulijá in the western sector.

Faults are also partly responsible for the distribution of the alluvial terraces. The alluvial plain is slightly inclined to the north, formed by clastic materials like sands, silts, and clays. Here the river has a different configuration, characterized by meanders, oxbow lakes, wetlands, lagoons, and swamps. The river was also responsive to tectonic features, providing a morphology of basin and range systems. This morphology is more obvious in the area between the mountain system and the alluvial plain where fluvial terraces from the effluents of the San Pedro, Chakamax, and Tulijá are located at different altitudes. Figure 7.1b shows a schematic section crossing the Usumacinta system from east to west, where the San Pedro River occupies a higher position than the Usumacinta and Chacamax Rivers in the uplift block. These terraces were formed during the Pleistocene, located at altitudes higher than 20 meters; and during the Holocene, at lower altitudes (Figure 7.1c). In the Pleistocene terraces, big urban centers like Palenque, Chinikihá, Pomona, and

Santa Helena developed (Figure 7.1, 1d); on the Holocene terraces, formed by floodplain deposits, middle sized sites are present. At least three levels of Holocene terraces are recognized (HT2, HT1, HT0) (Solís et al. 2013), as shown in Figure 7.1c.

Study Method

This study is based on the paleo-pedological record. Paleosols are good paleo-environmental proxies and, with climate information, they are indicators of past human activities and land use. In the Maya Lowlands, they have been used to register changes in environmental conditions (Cabadas et al. 2010; Dunning et al. 2006; Sedov et al. 2007) and human impact on the soil cover (Beach, 1998; Beach et al. 2008; Beach et al. 2009; Beach et al. 2011; Fedick et al. 2008; Fernández et al. 2005; Johnson, Terry, et al. 2007; Johnson, Wright, and Terry 2007).

We conducted a field survey along the Usumacinta near the town of Emiliano Zapata (see Figure 7.1), studying Holocene pedo-stratigraphy in detail. Four sections were described and sampled: two in the oldest Holocene terrace (HT2), Tierra Blanca I and Tierra Blanca II; and two in the HT1, El Pochote, and Vicente Guerrero (Figure 7.2; Solís et al. 2013).

Five profiles were described and sampled. Here we report the results of two of them, Tierra Blanca and El Pochote, where several pedo-stratigraphic units were recognized. In Tierra Blanca, these soil units are directly associated with the presence of artifacts of different ages. At El Pochote, no artifacts were recovered. Morphological descriptions were done in order to detect the differences in the soil development and sedimentation processes.

In the area of Chinikihá in the mountain system of Sierra de Chiapas (see Figure 7.1), we sampled another profile, taking advantage of the archaeological work undertaken in the core of the settlement. Thus, it is possible to make a comparison between two archaeological sites located in different landform positions: Tierra Blanca in the "open" alluvial plain, where the system is more dynamic; and, Chinikihá in a "protected" position near the Sierra.

Selected properties were evaluated. Colors were determined using Munsell Soil Color Charts (1975). Clay content was separated by gravity after the elimination of aggregating agents: H_2O_2 (15%) was used for soil organic matter (SOM), dithionite-citrate-bicarbonate (DCB) for iron oxides, and HCl (10%) for carbonates. pH was measured in H_2O in a 1:2 soil paste and measured using a potentiometer.

Only A horizons were used to evaluate the stable isotope composition ($\delta^{13}C$), which were obtained by Solís et al. (2013) from samples at Tierra Blanca and El Pochote. Samples from Chinikihá were processed in the Laboratory of Spectrometry of Stable Isotopes of the Institute of Geology at UNAM. A chronological frame for the study area has been constructed by using several AMS (Accelerator Mass Spectrometry) dates from Beta Analytic Laboratory (Solís et al. 2013), pedo-stratigraphy, and the presence of cultural materials.

Paleo-Environmental Results: Geomorphology

Profile Descriptions in the Alluvial Terrace

Tierra Blanca I and II (TBI, TBII)

We studied two sections in Tierra Blanca: the Tierra Blanca I (TBI) profile (1961366 N; 641218 E, 7 meters above sea level) and the Tierra Blanca II (TBII) profile (1961355 N; 641199 E, 7 meters above sea level; see Figure 7.1a). Sections are separated by only 50 meters and occupy the HT2 (Holocene terrace; see Figure 7.1b).

TBI has a more complete sequence that covers a longer time span. The base contains several buried paleosols with strong gleyic features (Gleysols) that were formed in the Late Pleistocene to Middle Holocene. There is no evidence of human occupation. This set of Gleysols is well separated from the upper materials by 1.5 meters of fine laminated sediment. Overlying this sediment we have recognized two paleosols (2, 3) with 2A, 2AB, 2C, 3A, 3AB 3BC horizons (Figure 7.3; Table 7.1) strongly affected by human activities and sedimentary processes. Particularly in 2A and 2AB, there is an artifactual mixture of different cultural periods including Classic ceramics and Postclassic burials containing ceramics. These materials are close to the present-day surface, which has a poorly developed soil only 20 centimeters thick.

In TBII, Gleysols are not present, but the younger paleosols are better developed and are separated from modern soil by one meter of alluvial sediment. The set of paleosol horizons is as follows: 2A, 2AC; 3A, 3C, 4Ck, 5Ass, 5Bss, 5BC, 5C. The latest horizons, belonging to the paleosol 5, are the best developed and contain ceramics from the Preclassic period. This paleosol shows strong dark colored vertic features in the 5Ass horizon, hard angular blocky structure, clayey slickensides, and vertical cracks. The fourth paleosol is a pedo-sediment (4Ck), containing common fragments of soils eroded from the previous surface as well as re-worked pedogenic carbonates and alluvium, indicating a period of landscape instability. Paleosols 2 and 3 are less developed, with similar soil profiles; but in TBII they are well separated by parent material, while in TBI they are welded in

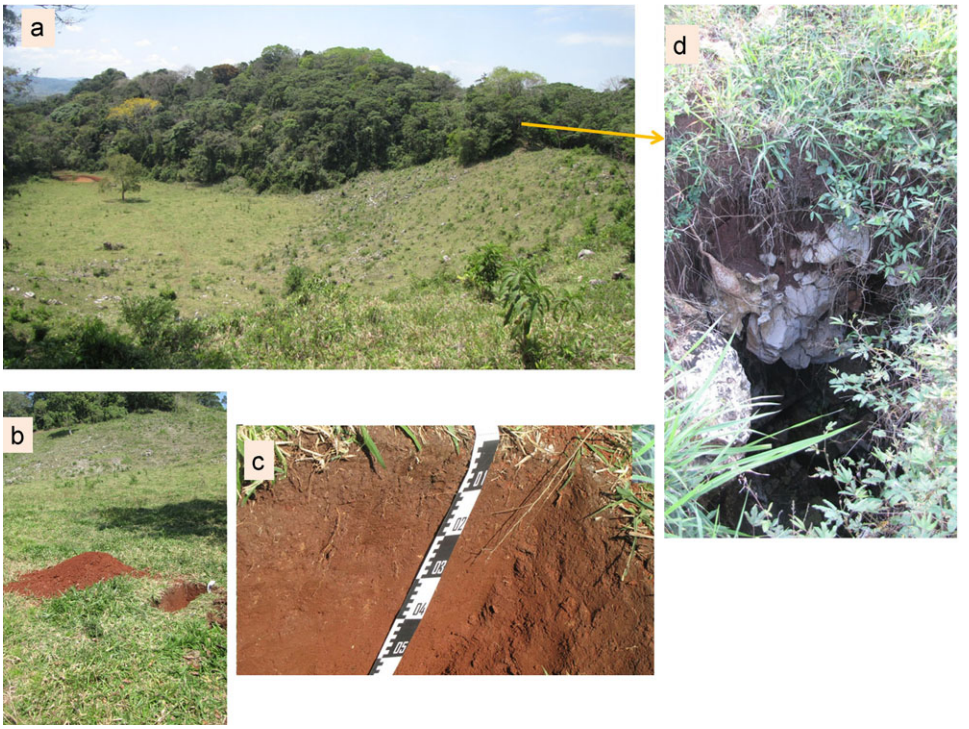

Figure 7.2. Chiniquihá soils: (a.) Landscape view, showing the differences in altitude; (b.) Rendzinas in the slope of the Sierra; (c.) and (d.) Luvisols at the valley bottom.

2A. Abundant artifacts have been found: Postclassic in 2A and 2C, and Classic in 3A, 3C. Modern soil signature of the carbon stable isotope composition is -21.9‰. 2A and 3A have a little bit higher values, -20.2% and -19.4‰, respectively.

El Pochote (POCH)

This section (1964202 N; 633601 E, 7 meters above sea level), located in younger terrace HT1, is constituted by seven paleosols (2, 3, 4, 5, 6, 7, 8; see Figure 7.1b). The modern soil has an AC horizon, preserving characteristics of the parent material (sandy alluvial sediment). The upper first paleosols (2, 3, 4) are poorly developed, showing loose structure and light colors, but the A horizons are slightly darker (see Table 7.1). Paleosol 4 is somewhat better developed and has abundant charcoal fragments. In contrast, underlying paleosols (5, 6 7, 8) have a higher degree of development and are more clayey, with the following horizons: 5Bg, 6Bgk, 6BCg, 7Ass, 7Bg, 8Ass, 8Bg, 8G, all of them with gleyic features (reddish mottling, Fe concretions). A horizons (7Ass and 8Ass) are very dark (see Figure 7.2; see Table 7.1) and have angular blocky structures, very compact and dense. $\delta^{13}C$ in values of the soil organic C are lower in the uppermost paleosols (-22.9% and -21.9‰ for 2A and 4A, respectively). The highest values correspond to paleosols 6 and 7, both having -17.6‰ (see Table 7.1). We did not find artifacts in this section.

All horizons from TBI, TBII, and POCH had pH values ranging from neutral to slightly alkaline (7 to 8), with low to moderate carbonates contents that are low in TBI and TBII (4% to 15%) and high in the Pochote (10% to 26%).

Profile Descriptions inside the Archaeological Site of Chinikihá—Natural vs. Human Affected Soils

Chinikihá is located in the Sierra de Chiapas (1926451.5 N; 643533.5 E, 130 meters above sea level; see Figure 7.1d) and is a large archaeological site. As the Sierra de Chiapas is constituted by folded limestones, it conforms with a karstic system in which soils show a high variability (see Figure 7.2), spanning thick, red, clayey soils or Luvisols to shallow, dark Rendzinas. Luvisols occupy the lowest positions in the valleys (Figure 7.4b, 7.4c), while Rendzinas are found in the hills and on the slopes, contrasting their presence with the limestone outcrops (see Figure 7.2d).

We have described three sections: one corresponds to the Luvisol profile in the bottom valley (see Figure 7.2b, 7.2c); the second is a Rendzina in the limestone ridge

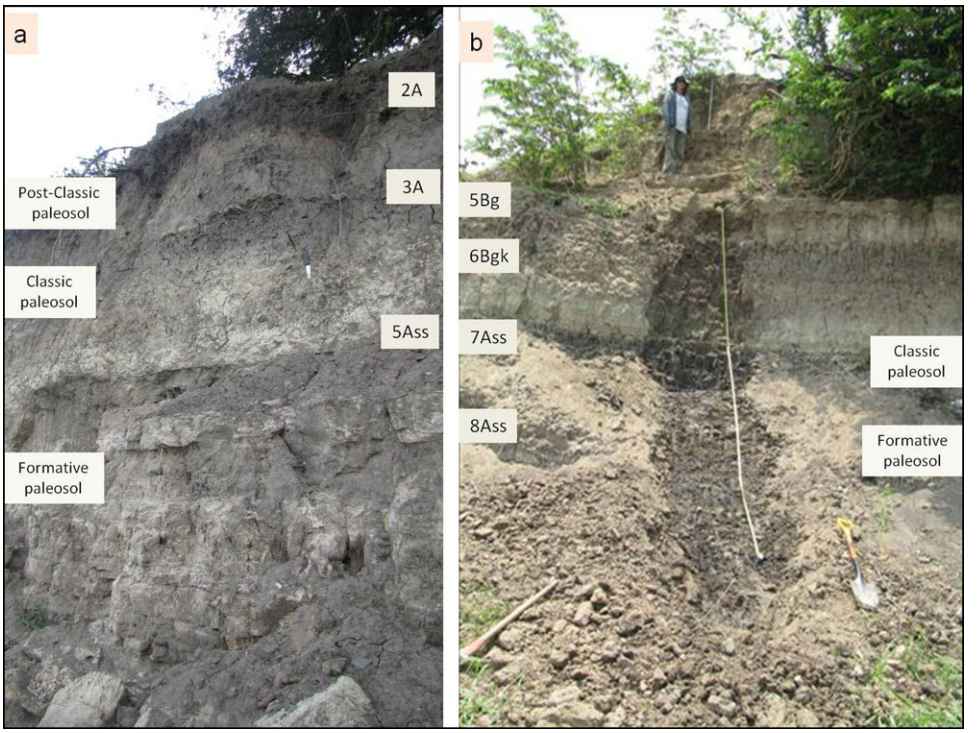

Figure 7.3. Pedological sections, showing the paleosols' stratigraphic location: (a.) Tierra Blanca II; (b.) El Pochote.

(see Figure 7.2d); and the last, inside the archaeological excavation (Operation 114), associated with an interesting midden located behind the Palace at the site of Chinikiha. It is highly plausible that the Chinikihá palace functioned as the residence for the ruling family.

Luvisols were more than one meter thick, with a dominant reddish brown color. The A horizon was shallow (15 centimeters thick) and dense. Underlying the A horizon was a clayey Bt horizon. It presented clay cutans, structured in angular blocks, and was very well developed; however, it was hard and dense, which limited root penetration (see Figure 7.2a). The Rendzina profile was 50 centimeters thick, but this depth was irregular, having an abrupt contact with the limestone (see Figure 7.2b). The Rendzina color was very dark brown with a high root density, and its structure was granular and porous.

In Operation 114 (see Figure 7.4), a Bt horizon was observed that was very clayey (75% of clay), belonged to a Luvisol (Figure 7.4c), and was buried by cultural remains.

The material used for the infillings—like the Bt horizon—were denser and more compact. Both materials, the Bt horizon and the infilling, had similar pH values (7.5 and 7, respectively) and color (see Table 7.1). Overlying the cultural structure, a less developed soil was present (Figure 7.4b). It was 30 centimeters thick, with A and AB horizons that were brownish and had a hard subangular blocky structure (see Figure 7.4).

Age of the Paleosols

The age of the paleosols was determined by several AMS dates from bulk organic matter. Although we do not have dates from all paleosols present in the alluvial terrace, the archaeological artifacts and paleosol morphology help to establish a chronological framework. Accordingly, we propose that 5Ass-TBII, 8Ass-POCH, and 3A in TBI, which were associated with ceramics belonging to a Preclassic culture, were formed during the same era (see Table 7.1). All of these paleosols had well expressed vertic features. Sample 2A-TBI containing ceramics from both the Maya Classic and Postclassic periods correlate with 7Ass-POCH, 3A-TBII, and 2A-TBII. The latter was associated with Postclassic ceramics.

Environmental and Land-Use Interpretation

Contrasting features may be found in the morphology of the alluvial valley paleosols as shown in Figure 7.5, and taking into account the TBII section, which includes all

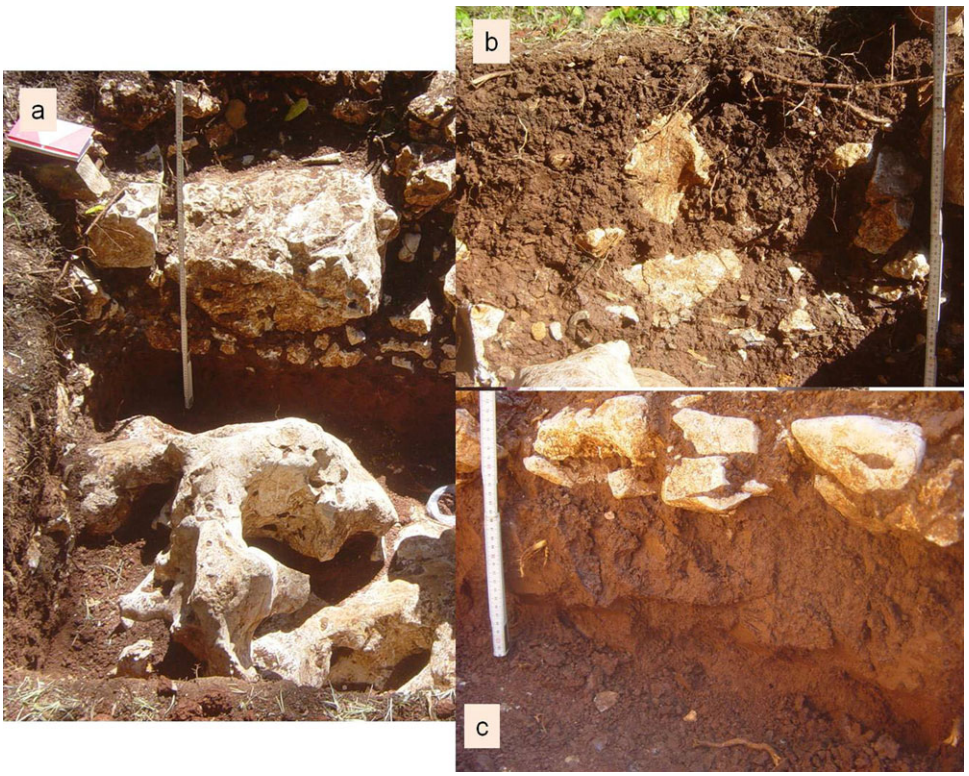

Figure 7.4. Operation 140 at the archaeological excavation: (a.) remains of a wall; (b.) Soil close to excavation surface; (c.) Buried soil showing similar characteristics of the Luvisol in Figure 7.2.

paleosol units and contains archaeological materials. Vertic features predominate in paleosols 3 in TBI, 5 in TBII, and in 8Ass and 7Ass of El Pochote. Humus accumulation is the main pedogenetic process in the younger paleosols found in the alluvial terrace.

In Chinikihá, however, we observe a different picture: two kind of pedogenesis are noticeable, one related to the plain and bottom valley positions, and another related to the mountainous system. This behavior is common in karstic areas (e.g., Yaalon 1997). Luvisols need a longer time to develop, while Rendzinas suffer from erosion and translocation processes. Consequently, the observed differences might indicate periods of relative landscape stability. In the Sierra de Chiapas, erosional processes take place on the slopes, leading to the accumulation of material in the valley bottom that leads to the formation of thick Luvisols; Rendzinas are consequently thinner.

On the other hand, paleosols in the alluvial terrace are formed in shorter time periods and within a more dynamic environment. In such positions, the influence of alluvial sedimentation is high—limiting the development of the soils, but contributing nutrients to them. These paleosols are less developed and younger than those observed in the mountain region.

In terms of environmental conditions, Luvisols form under humid climatic conditions for periods of several thousands of years; their formation probably covers most of the Holocene. Early Holocene humid conditions have been reported in other parts of the Maya lands as noted earlier (e.g., Hodell et al. 2001, 2007; Islebe et al. 1996; Leyden 2002; Mueller et al. 2009). However, the paleosols of the alluvial terraces demonstrate that this environment was not homogeneous in space and time. First, the Usumacinta River had several pulses of sedimentation and erosion that produced the terrace configuration labeled as HT2, HT1, and HT0 (see Figure 7.1, from oldest to youngest). Second, each pulse of sedimentation generated a new parent material for soil formation. In this way, paleosols in TBI, TBII, and POCH reflect periods of instability (where the river was more active and accumulated sediments) and stability (when the sedimentation stopped and pedogenesis started).

The presence of vertic paleosols, formed during the Preclassic, is evidence of a seasonal climate; a dry season, several months long; and a short rainy season. Such conditions also are necessary for the formation of Vertisols in other parts of the world (Wilding and Puentes 1988). We suggest that a seasonal climate combined with stable conditions permitted the formation of better developed paleosols

Table 7.1. Selected properties of paleosols in Tierra Blanca I and II and Chinikihá.

Horizon	Depth cm	Color dry	Features	Clay (%)	Calendrical Age (2σ)	$\delta^{13}C^{*}$
			Tierra Blanca I (TBI)			
AC	0–20	10YR 4/2	Sandy, weak structured, affected by recent human activities.	24.7		−21.9
2A	20–52	10YR 5/2	Very hard and compact subangular blocky structure. Ceramic and burials (human bones).	32.1		−20.2
2AB	52–80	10YR 6/2	Very hard, subangular blocky structure, abundant artifacts. Abundant charcoal.	33.7		
2C	80–140	2.5Y 6/2	Silty. Colluvial material, with no pedogenic structure.	27.1		
3A	140–155	2.5Y 7/1	Clayey. Fine and very hard subangular blocky structure, slickensides are present in ped surfaces, vertical cracks.	45.6	830–790 B.C.E.	−19.4
3AB	155–170	2.5Y 7/2	Clay. Fine and very hard subangular blocky structure.	45.4		
3BC	170–185	2.5Y 8/2	Silty. Less structured, friable.	35.9		
sediment	185–451	2.5Y 8/2	Silty. Laminated. No signs of pedogenesis.	36.3		
			Tierra Blanca II (TBII)			
AC	0–100		Alluvial sediment poorly affected by pedogenesis.	14.3		
2A	100–130	2.5Y 4/2	Silty. Structure is well developed, with fine subangular blocks. Post-Classic ceramic.	44.2		−22.6
2AC	130–195		More silty and less structured.	31.5		
3A	195–210	2.5Y 5/3	Silty clayey. Brownish gray. subangular blocky structure, compact. Presence of ceramic of Maya Classic.	33.5		−20.3 −25.0
3C	210–270	2.5Y 5/3	More silty and less structured.	20.3		
4Ck	270–290		Silty pedosediment. Reworked soil fragments and carbonate concretions, horizontal alignment.	37.9		
5Ass	290–315	2.5Y 4/1	Clayey. Structure in very hard angular blocks, slikensides, and carbonate concentrations. Ceramic of the Formative period.	57.1	390–350 B.C.E.	−16.5
5Bss	315–340	2.5Y 5/3	Clayey. Slickensides. Concentrations of carbonates in the ped surfaces.	55.3		−18.3 −10.0
5BC	340–365	2.5Y 5/3	More silty. Here, there are also abundant ceramic fragments	44.3		
5C	365–515	2.5Y 5/2	Colluvial sediment. Silty sand. It has incorporated rests of gleyic soils.	30.3		
C	0–38	2.5Y 5/3	Sandy, with low degree of pedogenesis.	19.2		−22.9

(Continued)

Table 7.1. (continued)

Horizon	Depth cm	Color dry	Features	Clay (%)	Calendrical Age (2σ)	$\delta^{13}C^{*}$
			El Pochote (POCH)			
2AC	38–50	10YR 7/4	Low structured. Sandy.	16.3		
2C	50–71	2.5Y 6/4	Sandy, not structured. Laminated sediment.	20.0		
3A	71–88	2.5Y 5/3	Sandy, with a weak structure.	12.0		
3C	88–120	2.5Y 6/3	Sandy, poorly structured.	9.3		−21.9
4A	120–160	2.5Y 7/3	Sandy. Subangular blocky structure, friable, abundant charcoal fragments.	16.8		
4AC	160–176	2.5Y 7/3	Coarser subangular blocky structure, friable.	30.4		
4C	176–326	2.5Y 6/4	Sandy, laminated sediment.	25.0		
5Bg	326–356	2.5Y 7/3	Sandy. Friable subangular blocks. In the limit with 5Bgk there is a layer of coarser material.	12.8		
6Bgk	356–446	2.5Y 7/3	Silty. Prismatic to columnar structure, very hard and very well developed, with small carbonate hard concretions. Some shells are present.	20.3		
6BCg	446–476	2.5Y 7/3	Clayey. Subangular blocky structure, very hard.	44.8		−17.6
7Ass	476–528	2.5Y 6/2	Clayey. Columnar to prismatic structure, breaks into angular blocks. Slickensides.	47.1	C.E. 640–690	
7Bg	528–616	2.5Y 7/2	Clayey. Subangular blocky structure more friable than 7Ass. dense	52.8		−17.6
8Ass	616–628	2.5Y 6/1	Clayey. Very hard, angular blocky structure, slickensides.	45.9	180–30 B.C.E.	
8Bg	628–672	2.5Y 7/3	Clayey. Subangular blocky structure. Slickensides.	67.9		
8G	672–702	2.5Y 5/3	More sandy, showing redox features.	23.9		
			Chinikihá (Luvisol)			
A	0–15	5 YR 3/3	Subangular blocky structure, dense, low density of roots.	60.0		
Bt	15–80	2.5YR 3/6	Very clayey, subangular blocky structure, very dense and compact. Poor root penetration. Some fragments of limestone are present at different depths. Bright clay cutans on surface of the aggregates.	75.7		
			Chinikihá (Rendzina)			
A	0–20/50	10YR 3/1	Granular structure, very well developed. High density of roots, very aggregated and clayey.	55		−25.6

(Continued)

Table 7.1. (continued)

Chinikihá (Operation 140)					
A	0–18	7.5YR 4/6	Subangular blocky structure, slightly compacted, but still porous.	51.7	−25.6
AB	18–29	5YR 4/6	Subangular blocky structure, very dense and hard.	65.6	
cultural	29–61	5YR 4/6 (infillings)	Floor made of stones, infilled by reddish, clayey material.	35.7	
Btb	61–80	5YR 4/6	Subangular blocky structure, very well developed, very dense and compact. It has bright clay cutans and shows limestone fragments and ceramic.	75.6	

*According to Solis et al. 2013, except for the samples of Chinikihá

prior to the Classic and Postclassic, when these particular soils were more affected by erosion and sedimentation processes.

Paleosols in the river bank demonstrate better attributes for agriculture and would have been able to sustain a population longer based on high organic content, carbonates and clay, and a neutral pH, as well as a porous structure that permitted good root penetration and aeration. In contrast, in higher terraces and in the Sierra de Chiapas, Luvisols are more clayey, more compact, and contain less organic matter. Rendzinas have better attributes, but they are shallow and discontinuous. Compare values of $\delta^{13}C$, Chinikihá values are very low (-25.6‰); thus, we suggest that the soils were not affected by agriculture. Paleosols in Tierra Blanca and El Pochote show the highest $\delta^{13}C$ value of -16.5‰—evidence for the use of C4 and CAM plants. Maize is a typical C4 plant; thus, the signature that was obtained probably is due to the mixture of maize and C3 plants from humid forest. Whatever the case, it clearly indicates the use of these paleosols in agriculture. Fernández et al. (2005) and Johnson and colleagues (Johnson, Terry, et al. 2007; Johnson, Wright, and Terry 2007) have documented similar variations in the carbon isotope signatures in Guatemalan soils and attribute these variations to changing land use.

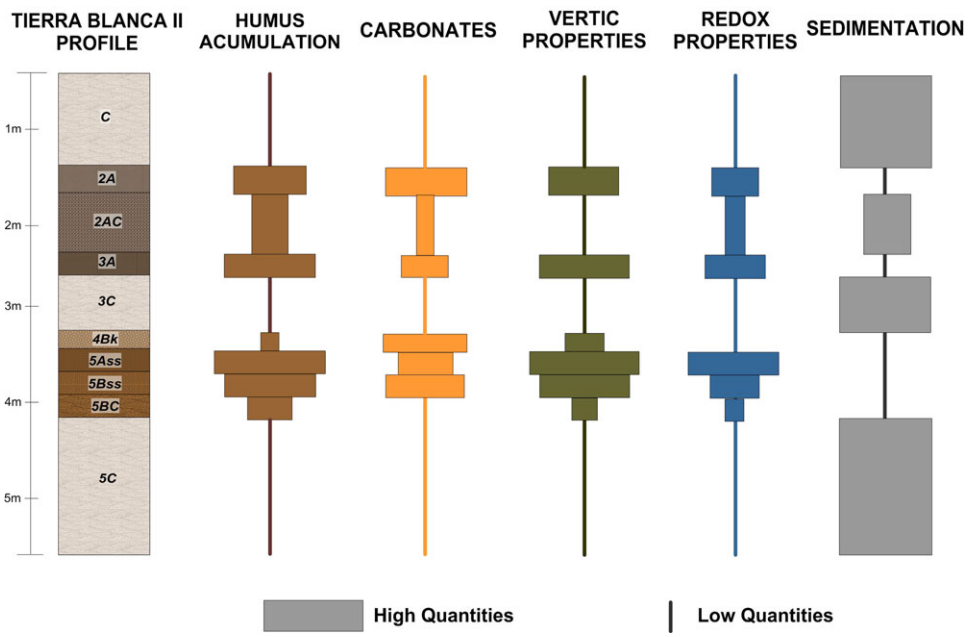

Figure 7.5. Scheme of morphological characteristics of paleosols at Tierra Blanca II, showing contrasting differences between those formed in Post-Classic, Classic, and Formative periods.

Although similar, paleosols in El Pochote and Tierra Blanca show significant differences. In El Pochote, reductomorphic features, related to periods of soil water-saturation, are more frequent. This feature would have developed during seasonal inundations and is probably the reason that no artifacts are found in these soils. However the signature of $\delta^{13}C$ at -17‰ can be attributed to ancient maize agriculture.

Final Remarks: Spatial Differentiation of Occupation Type and Evolution Controlled by Landscape and Soil Cover Structure?

The distribution of archaeological sites of different types and histories shows a clear relation to geomorphic position, geological setting, and soil type. The most ancient (Preclassic) rural settlements have been registered in the lowest river terrace, nearest to the Usumacinta River and in areas that were periodically flooded. In this setting, people inhabited a flat land surface covered by thick cumulic Luvisols that were rich in humus and nutrients and that had a high physical quality. It is important that these original settlements persisted throughout the Classic period and even survived the Terminal Classic collapse, maintaining the same characteristics of minor rural sites.

The higher terraces, more distant from the river and closer to the mountain ridges, were occupied later during the Classic period by larger and more complex settlements. These landforms have a more curved relief and are covered with more developed red soils that have a lower agronomic quality and are poorer in humus and nutrients. Major urban centers are located on the calcareous mountain ridges (see Figure 7.1). These centers, like Palenque, Piedras Negras Yaxchilán, Pomoná, Santa Elena, Reforma Moral, and Chinikihá, flourished during the Classic period. All show high population densities, impressive cultural developments, and a high concentration of political power. These centers suffered a complete abandonment during the collapse that occurred in the Terminal Classic period at the beginning of the 9th century C.E. The mountains are formed of Tertiary limestones subjected to karst processes that in a humid tropical environment demonstrate the highest erosional intensity when occupied by humans. These processes generated a very contrasting relief consisting of profound circular closed or half-closed depressions surrounded by sharp, steep ridges. Underground cavities, caves, and galleries are frequent; some are partly filled with groundwater. The soil mantle is strongly differentiated: the ridges have very thin, stony, discontinuous soils alternating with the limestone outcrops; the depressions contain thick, red, very clayey soils that are compact and hard. Both components of the mountain soil cover are difficult for cultivation and have a much lower agronomic quality than the alluvial soils of the lower terraces.

Obviously for initial colonizing populations focusing on an agronomic viewpoint, the lower terraces present the most attractive landscape in terms of easy access and soil fertility. Nevertheless, floods presented certain risk. That said, however, in the terrace profiles we observed higher soil development and minor alluvial sedimentation features corresponding to occupation during the Classic period. This indicates that the surface was rather stable and that flooding processes were rare and weak.

The Sierras region clearly presented the most hostile environment for agriculture because of relief complexity and poor soil quality. Interestingly, during Preclassic times, this same landscape provided an excellent stage for ritual activities in karstic caves. A better understanding of the factors responsible for drawing population to the Sierras region will need to be detailed through future research. However, we are able to cautiously suggest the following "attractors" as favorable conditions for the development of an urban pattern that concentrated political power:

- High position in the relief allows visual control of the adjacent low territories.
- More defensive settlement positions exist on high relief.
- The stone material for urban and ceremonial constructions is abundant in the more elevated settings.
- The karstic relief presents a specific advantage for urban development. The set of interconnected flat, draining, circular karstic depressions are a perfect base to create small squares—plazas surrounded by habitation areas developed on artificial terraces of surrounding slopes. We can conclude that karstic relief formed part of the urban design in several examples in the Sierras region, especially Chinikiha.
- Subsurface water-filled karstic hollows provided a permanent water supply for urban dwellers.

The comparison of this set of attractors (or new ones) among human communities located in the alluvial flood plains and the Sierras regions are an important avenue for future research in the Usumacinta region. The divergent trajectories and comparative success of settlements located in the plains and Sierras regions can be traced and understood in these terms.

In closing, we note the dynamic role of the karstic environs and the clever landscaping adjustments and alterations made by the Maya of the northwestern Maya lowlands. Our regional case study emphasizes the resilience of these populations in adapting to the oscillations of a changing climate

and the behaviors of a human induced erosional cycle. We hope that a careful reevaluation and reassessment of these ancient settings and the people that occupied and utilized them will be allowed before additional urban expansions by our modern world.

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